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(54) IMPROVEMENTS IN OR RELATING TO GAS LASERS

(71) We, ELLIOTT BROTHERS (LONDON) LIMITED, of Century Works, Lewisham, London, S.E. 13, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to gas lasers.

In the most general terms, a gas laser comprises an elongated, gas-filled cavity with a mirror at either end of the cavity and means to stimulater laser action in the gas, causing it to emit "light", which term, as used herein, includes ultra-violet and infra-red radiation, as well as visible light. The actual wavelength or wavelengths of emitted "light" will be dependent on the sub-atomic properties of the gas or gases employed in the laser.

Now, it has been found that the output power and efficiency of a CO_2 (carbon dioxide) laser are limited by dissociation of CO_2 and consequent build up of CO (carbon monoxide) during operation of the laser. The dissociation reaction is as follows:

$$CO_2 + e^- \rightarrow CO + O^- \rightarrow CO + O + e^-$$

This loss of power and efficiency is particularly apparent in sealed lasers, but can be off-set in flowing (unsealed) lasers by removal of the CO and O_2 (oxygen), and by replacement of the CO_2. The more rapidiy the CO_2 is replaced, the better is the continuous performance of the laser. However, this improved performance has hitherto only been achieved by replacing the total gas mixture, of which He (helium) is the principal component, not merely by adding extra CO_2 since this does not remove the CO. Since helium is a relatively expensive gas, it will be obvious that such a replacement procedure is costly. This will also apply to gas lasers employing other gas mixtures.

It is therefore an object of the invention to provide a method of operating a gas laser, a laser gas circulation system, and a combination of this system with a gas laser, particularly but not exclusive a CO_2 laser, in which the maintenance of long term performance against the deleterious effects of dissociation of the gas or at least one of the gases employed in the laser is less costly than the replacement of the gas or gas mixture employed in the laser.

According to one aspect of the invention, a method of operating a gas laser includes the step of circulating the gas, or mixture of gases, employed in the laser, over a catalyst whose properties are such as to reassociate a gas or gases dissociated during use of the laser.

Said method preferably includes the further step of changing the temperature of the gas or gases leaving the laser to an optimum temperature for catalytic reassociation before the gas or gases are circulated over the catalyst.

Said method preferably also includes the further step of changing the temperature of the gas or gases, after their passage over the catalyst and prior to their re-entry to the laser, to an optimum temperature for laser action.

According to another aspect of the present invention, a laser gas circulation system comprises means to circulate the gas, or mixture of gases, employed in the laser, over a catalyst whose properties are such as to reassociate a gas or gases dissociated during use of the laser.

Preferably, means are provided to change the temperature of the gas or gases leaving the laser to an optimum temperature for catalytic reassociation before the gas or gases are circulated over the catalyst.

Preferably also, means are provided to change the temperature of the gas or gases, after passing over the catalyst and prior to

their re-entry to the laser, to an optimum temperature for laser action.

Preferably, the mechanical properties of the catalyst, and of any support for the catalyst, are such that particles of the catalyst (and/or of its support) do not become entrained in the stream of circulated gas or gases whereby the gas in the laser may be kept substantially free of foreign material which might degrade operation of the laser, and are also such that as large an area of catalyst as possible is presented to the circulated gas.

According to a further aspect of the present invention, there is provided a combination of a gas circulation system as defined above, and a gas laser.

In a CO_2 laser, the catalyst may be platinum, and is preferably supported on a honeycomb of alumina such as to allow substantially unimpeded flow of gas over the platinum catalyst while firmly binding the platinum so that particles of platinum do not become entrained in the stream of circulated gas or gases.

Thus the invention provides a gas laser in which the performance of the laser is safeguarded against deleterious effects of gas dissociation, and which can also ensure an optimum gas temperature within the laser.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings wherein:—

Figure 1 is a schematic longitudinal cross-section of a gas laser;

Figure 2 is a schematic gas flow diagram of the invention;

Figure 3 is an oblique view, part of which is to an enlarged scale, of a catalyst member suitable for use in the invention; and

Figure 4 is a schematic diagram of a possible modification of the laser of Fig. 1.

Referring first to Fig. 1, a gas laser 10 illustrated therein by way of example of a gas laser which may incorporate the invention, comprises an elongated optical cavity 12 whose ends are terminated by a fully reflective mirror 14 and a partially reflective mirror 16. The mirror 16 is conveniently of germanium. The cavity 12 is bounded by a gas-tight envelope 18 of which the mirrors 14 and 16 form part thereof. The envelope 18 is conveniently a glass tube which may be water cooled by means not shown, and incorporates annular end electrodes 20 and 22, and an annular central electrode 24, sealed in to the envelope 18. The mirrors 14 and 16 are mounted in respective mirror support members 26 and 28 connected to the envelope 18 by respective flexible gas-tight members 30 and 32, such as metal bellows.

Adjustment of the mirrors 14 and 16 to ensure parallelism of the mirrors 14 and 16 (which requirements are well known in the art) may be undertaken by screws 34 in the mirror support members 26 and 28 bearing against brackets 36 and 38 mounted on a support member 40 serving rigidly to support the components of the laser 10.

A high voltage direct current supply 42 is connected to the electrodes 20, 22 and 24, through suitable ballast resistors 44 and 46, to produce ionisation in a gas or mixture of gases in the cavity 12 such as to permit laser action in the gas whereby to produce a laser beam 48 as is well known in the art. The ballast resistors 44 and 46 suitably limit and stabilise the current. (As an alternative to direct current, radio frequency power could be applied to the gas, or as a further alternative, a flash tube (not shown) could be arranged adjacent the envelope 18 for pulse, as against c.w. (continuous wave), operation of the laser 10).

The laser 10 is adapted for circulation of gas in the cavity 12 by means of an inlet port 52 formed in the electrode 20 and an outlet port 54 formed in the electrode 22. (The ports 52 and 54 could be formed in other components of the laser 10).

Referring now to Fig. 2, which is a schematic diagram of a gas circulation system in accordance with the invention, the outlet port 54 is connected by way of a gas flow control valve 56 to a gas heating device 58 followed by a catalyst chamber 60, succeeded by a gas cooling device 62, a gas circulation device 64, a further gas cooling device 66, a gas tap 68, and a further gas flow control valve 70 leading to the inlet port 52.

Gas leaving the laser 10 by way of the outlet port 54 has its flow rate controlled by the gas flow control valve 56 in its passage to the gas heating device 58 wherein the gas is heated to an optimum temperature for catalytic reassociation of the dissociated gas or gases in the catalyst chamber 60. (The form and nature of the catalyst used in the catalyst chamber 62 will be subsequently described with reference to Fig. 3).

After its passage through the catalyst chamber 60, the gas is cooled in the gas cooling device 62 and is then passed through the gas circulation device 64 which serves to circulate the gas round the circulation means. The gas circulation device 64 preferably takes the form of "Roots blower", that is a meshed multi-lobed multi-rotor positive displacement device.

Thereafter the gas passes through the further gas cooling device 66, which serves to remove any heat which may have been introduced in to the gas in its passage through the circulation device 64, and to reduce the temperature of the gas to an optimum temperature for laser action in the laser 10.

Though not forming part of the invention, the remainder of the system illustrated in Fig. 2 will now be described for completeness. The gases forming the gas mixture used in the laser 10, for example CO_2, He, and N_2 (nitro-

gen) in the case of a CO_2 laser, are provided from gas storage devices 72, 74, and 76, conveniently cylinders containing the respective gases in a high-pressure state (for compact storage). Flow control valves 78, 80 and 82 control the relative rates of outflow of gases from the respective gas storage devices 72, 74 and 76 (to ensure correct proportionality), a gas tap 84 serving to control the total outflow of gases into the circulation means, and in to the laser 10.

A vacuum pump 86, of any suitable type, serves to exhaust the laser 10 and its associated gas circulation system, prior to filling of the laser 10 by a suitably proportioned gas mixture from the gas storage devices 72, 74 and 76, thus enabling the setting up of the laser 10 for operation. The vacuum pump 86 may also serve continually to remove a portion of the gas mixture from the laser 10 where it is not wished to totally recirculate the gases, for example if the gases were contaminated, such as by vapours from the hot zones of the gas circulation system or by vapours from the circulation device 64 (though such contamination could be mitigated by the provision of a cold trap (not shown)). The vacuum pump 86 can be isolated by means of a gas tap 88.

Referring now to Fig. 3, a form of catalyst suitable for use in the catalyst chamber 60 comprises a honeycomb (hexagonal) matrix 90 of alumina serving to support and firmly bind to itself a quantity of finely divided platinum (not shown). The overall shape of the matrix 90 conveniently is a cylinder, of one inch length and two inches diameter (bottom-left of Fig. 3), and the honeycomb may have a one-eighth inch pitch. The upper-right portion of Fig. 3 shows a portion 91 of the matrix 90 to a much enlarged scale to show more clearly the form of the matrix 90. A plurality of matrices can be employed according to the conditions of gas flow.

Although platinised alumina is preferred for the catalytic reassociation of dissociated CO_2 from the laser 10, other suitable catalysts may be employed within the scope of the invention.

The nature of the support for the catalyst should be such that it presents as little impedance as is practicable to gas flow across the support, and that it presents as much area of catalyst as possible to the gas while binding the catalyst as firmly as possible to prevent particles of catalyst from becoming entrained in the stream of gas, thereby obviating contamination of the gas.

Fig. 4 illustrates a possible modification of the laser 10 (Fig. 1) to reduce overall length. (Those parts in Fig. 4 which correspond to the parts of the laser 10 in Fig. 1 have been given the same reference numerals). The laser is effectively folded in half about its midpoint, a 180° reflecting device 92 comprising two 90° reflecting surfaces serving to reflect the laser beam 48 to ensure proper passage of the beam 48 through the cavity 12 between the mirrors 14 and 16. The laser could be "folded" more than once further to reduce overall length.

While the above described embodiments of the invention refer particularly to a CO_2 laser, the invention is applicable to other types of gas laser. The gas laser employed may be a low pressure (approx. 10 Torr) laser or a high pressure (20—30 Torr) laser.

Lasers to which the invention is applied can be continuous or pulsed lasers, and while applications of such lasers are particularly envisaged in the realm of laser cutting of cloth, welding of synthetic fibres, and cutting of patterns in fabrics, other applications are possible, such as in telecommunications.

WHAT WE CLAIM IS:—

1. A method of operating a gas laser, including the step of circulating the gas, or mixture of gases, employed in the laser, over a catalyst whose properties are such as to reassociate a gas or gases dissociated during use of the laser.

2. A method according to Claim 1 including the further step of changing the temperature of the gas or gases leaving the laser to an optimum temperature for catalytic reassociation before the gas or gases are circulated over the catalyst.

3. A method according to Claim 1 or Claim 2, including the further step of changing the temperature of the gas or gases after their passage over the catalyst and prior to their re-entry to the laser, to an optimum temperature for laser action.

4. A laser gas circulation system, comprising means to circulate the gas, or mixture of gases, employed in the laser, over a catalyst whose properties are such as to reassociate a gas or gases dissociated during use of the laser.

5. A laser gas circulation system according to Claim 4, including means to change the temperature of the gas or gases leaving the laser to an optimum temperature for catalytic reassociation before the gas or gases are circulated over the catalyst.

6. A laser gas circulation system according to Claim 4 or Claim 5, including means to change the temperature of the gas or gases, after passing over the catalyst and prior to their re-entry to the laser, so that the gas or gases on entering the laser are at an optimum temperature for laser action.

7. A laser gas circulation system according to any of Claims 4 to 6, wherein the mechanical properties of the catalyst and of any support for the catalyst are such that particles of the catalyst (and of its support) do not become entrained in the steram of circulated gas or gases whereby the laser may be kept substantially free of foreign material which might degrade operation of this laser.

8. A laser gas circulation system substantially as hereinbefore described with reference to Figs. 2 and 3 of the accompanying drawings.

9. A combination of a laser gas circulation system according to any of claims 4 to 8, and a gas laser.

10. A combination according to claim 9, wherein said laser is a CO_2 laser.

11. A combination according to Claim 10 wherein the catalyst is platinum.

12. A combination of a laser gas circulation system and a gas laser, substantially as hereinbefore described with reference to Figs. 2 and 3, or Figs 1, 2 and 3, or Figs. 2, 3 and 4 of the accompanying drawings.

13. A method of operating a gas laser substantially as hereinbefore described.

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1256398 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

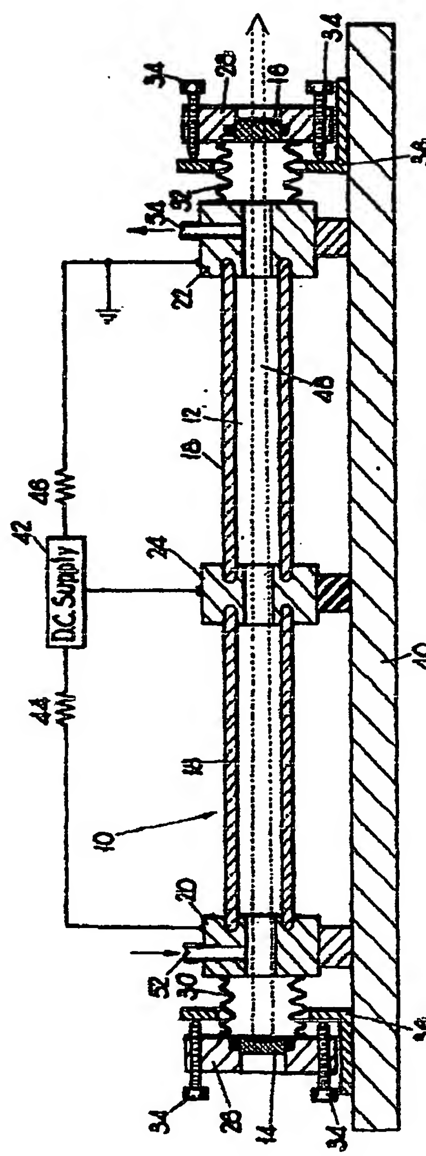

Fig.1

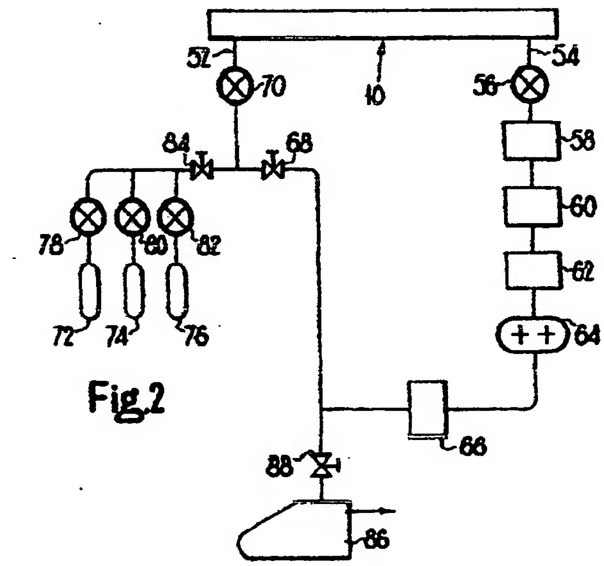

Fig.2

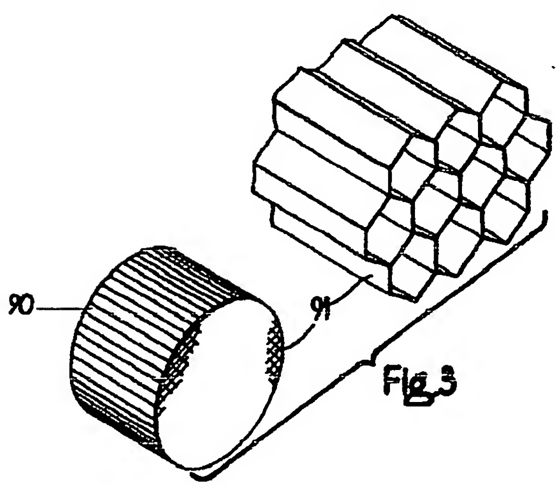

Fig.3

1256398 COMPLETE SPECIFICATION
3 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 3

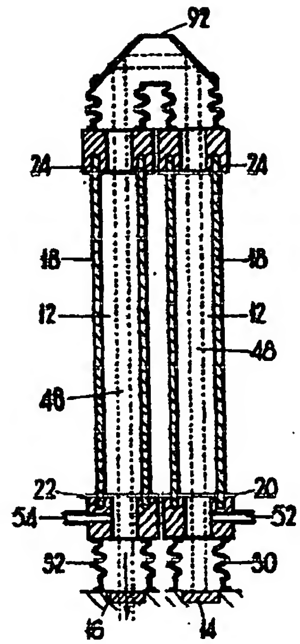

Fig.4